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PHOTOMETRIC AND CCD DIRECT IMAGE OBSERVATION OF COMET ENCKE

GRANT BP-724892

Final Report

For the period 19 June 1980 to 1 August 1981

Dr. Richard E. McCrosky

Principal Investigator

July 1981

Prepared for

Jet Propulsion Laboratory

Pasadena, California 91103

Smithsonian Institution
Astrophysical Observatory
Cambridge, MA 02138

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and the Harvard College Observatory
are members of the
Center for Astrophysics

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This report details our attempts to assist in the determination of the rotation rate of P/Encke by detecting, photoelectrically, periodic variations in brightness.

I. Photoelectric Photometry

Photometry of Encke was scheduled for the 61" telescope at Agassiz Station for the dates (UT) of October 5 and October 7-12. In addition, short periods of 8 nights during the interval September 24-October 3 were employed to test various aspects of the special system, described below, required for photometry of this rather fast moving object.

Encke presented three problems:

1) Its position was somewhat uncertain. The two available ephemerides — by Marsden and Yeomans — differed by nearly 0.5 arcmin on October 10.

2) Encke was expected to be faint. Since seeing as poor as 6" occurs about 25% of the time at Agassiz, we needed to be prepared for an invisible Encke.

3) The comet's motion would be of the order of 3 arcsec/minute and telescope tracking of the comet would be desirable for long integration times.

We resolved the problem of the comet's position on October 8 by making a photographic astrometric observation on the 61". This indicated that the

Marsden ephemeris was the better of the two but that a correction of about 10", principally due to parallax, was needed. With hindsight, we should have made this observation earlier. In addition to resolving the question of position, we also learned that the comet was much fainter than we expected and were alerted to the importance of the second problem.

An understanding of our approach to the last two problems requires a description of three special telescope and focal plane motion we regularly employ when making astrometric observations of comets and asteroids. The photometer was carried on the Newtonian double-slide (and rotatable) plate holder assembly. The X and Y coordinates can be read to .01 inches with micrometer and θ to 1° by a scale. The X motion can also be driven in steps of 1/8000 inch by a stepping motor at periods greater than about .04 secs/step. Thus, to cause the photometer field to track Encke (while the telescope tracks stars), one rotates the double-side to the position angle of Encke's motion and drives the X-axis (about ½ sec/step) at Encke's rate.

An additional feature of the telescope permits one to make precision offsets (±5 arcsec over several degrees) from one object to another. In preparation for our observing run, we made astrometric observations of the comparison stars recommended by A'Hearn and Millis and used these also as offset standards.

Finally, the actual offsets required at any given time were provided by a special addition to the computer program that handles the photoelectric observations. The computer read-out was available at the telescope.

The observing procedure is probably now obvious. Measurements were made of one of the comparison stars in a standard, sidereal manner. The observer then interogated the computer on the required offset to Encke. At the same time this offset was initiated, the comet tracking motor was started. Thus when the offset was complete after a minute or so, Encke should have appeared in the photometer diaphragm and remained there.

But of course we experienced the same problem as all other observers — Encke was never bright enough to see. In fact, our disappointment may have been greatest of all since we had photometric skies and reasonable seeing ($\sim$2-3") for almost all of the 6 day prime run time — a sequence of nights three times better than would be predicted on the basis of the Agassiz statistics.

It would not have been impossible to perform some photometry on an invisible Encke. Since we were not aware that we were not alone with our problem, we continued each night to attempt to detect Encke photoelectrically by performing manual roster scans, using the micrometer, in the region of Encke's position. This was not a terribly satisfactory procedure. One must watch the integrated counts as they appear on the monitor and try to determine, in real time, whether or not significant variations have occurred. But we attempted it several times each night. Occasinally a faint object would seem to show in the counter but never anything with Encke's motion. We concluded that Encke must have been fainter than 15th but this only confirmed our earlier photographic observation.

II. CCD Imaging

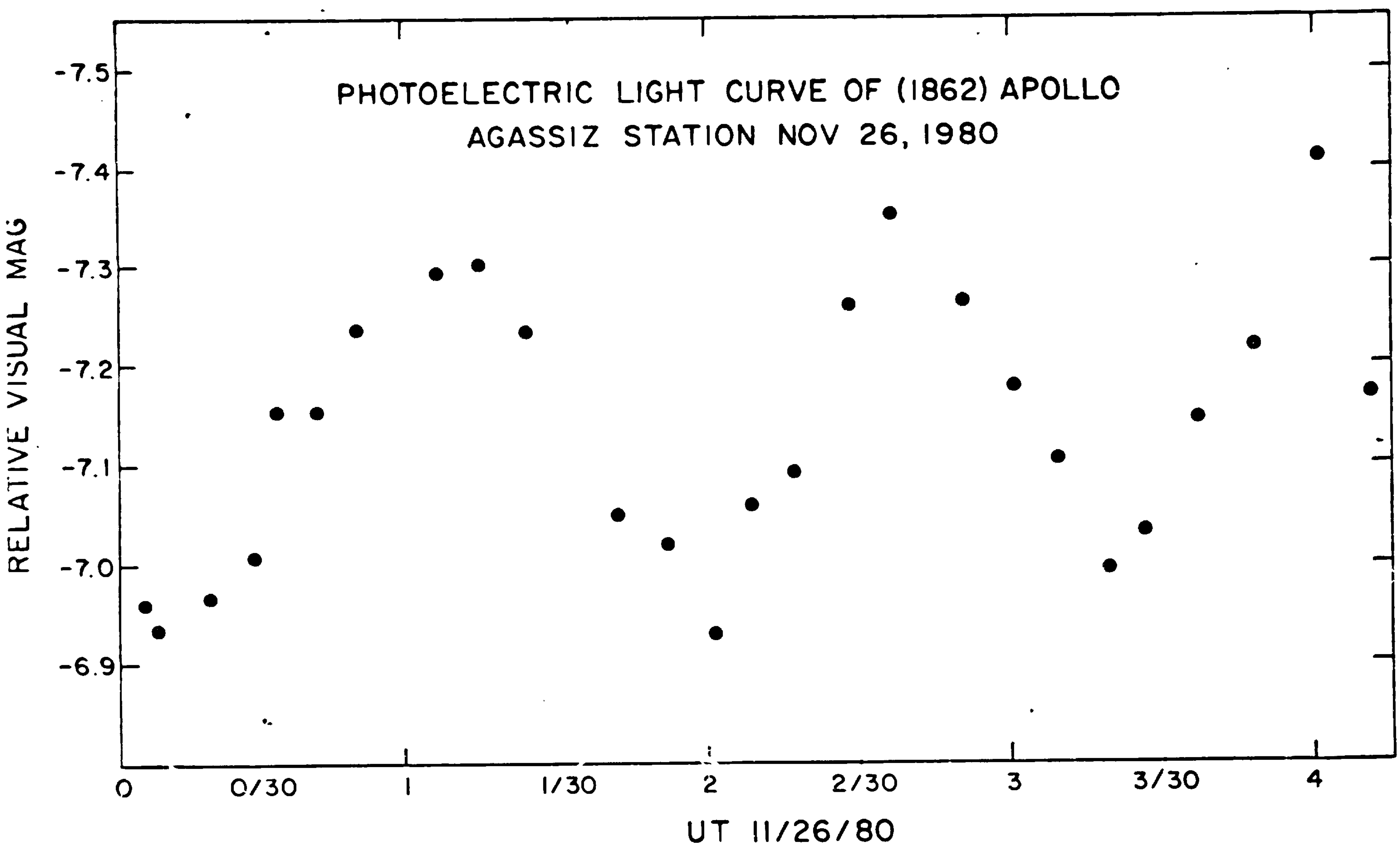
We were scheduled for frequent access to the Mt. Hopkins 24" on those dark nights in October and November when the CCD camera was at focus. The 24" primary was removed from the telescope in July for re-coating by a vendor. It was to be re-installed in early September, 1980. The vendor — in what must be considered a major blunder — ruined the surface of the mirror while in the process of removing their first, and unsuccessful, coating attempt. Several months passed before the vendor accepted responsibility. The repolished and coated mirror finally arrived at Mt. Hopkins in February 1981.

We tried to salvage some of this part of our program by scheduling time on the Mt. Hopkins 60" in early December. Four partial nights of CCD time, just before dawn, were made available but after two attempts it was clear that the comet's position, its great rate of motion and its large size all conspired to make the observations worthless. The killing problem was the rate; the motions of this telescope could not be biased off of sidereal enough to track on the comet.

III. The Good News

The proto-type earth crosser, (1862) Apollo, made a close approach to Earth in November, 1980. (We maintain a certain fondness for this object since this observatory was responsible for its recovery in 1973). Having learned nothing about the rotation rate of Encke, we turned to Apollo in the hopes of assuaging our disappointment. In many respects, photometry of Apollo duplicated the problems encountered in the Encke attempt. We were able to use almost all of the techniques and instrumentation developed in the previous months. Apollo — unlike a comet — was predictably bright enough but unfortunately much of the close approach time fell during bright moon. We made our first observation on November 16-17 after receiving an improved ephemeris from Marsden. Limits placed by available observing time and clouds permitted only 20 minutes worth of data but these were sufficient to demonstrate that Apollo would show large variations and, probably, a short period; $\Delta m \gtrsim 0.1$ in 15 minutes. On November 19-20 the moon was already too bright for useful photometry with the large diaphragm needed to match the poor seeing. The moon interfered for the next four nights and clouds for the following two. On November 25-26 we obtained good data for nearly four hours. The results are reproduced in Figure 1. The amplitude ($\gtrsim$ 0.4 mag) and period ($\lesssim$ 3 hours) are, respectively in the high and low, extremes of the distribution of all asteroids.

An additional snippet of the light curve was observed during the next available night, November 29-30 (Figure 2), but there is not sufficient information to tie this to the preceeding observation. No further observations were attempted.


PHOTOELECTRIC LIGHT CURVE OF (1862) APOLLO
AGASSIZ STATION NOV 26, 1980
RELATIVE VISUAL MAG
-7.5
-7.4
-7.3
-7.2
-7.1
-7.0
-6.9
0
0/30
1
1/30
2
2/30
3
3/30
4
UT 11/26/80